Compact and low resolution spectrometer for the inversion of water vapour total column amounts

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Water vapour (H_2O) is the main responsible atmospheric gas that regulates the weather and climate and contributes with about 90% of the Earth´s natural greenhouse effect. The continuous cycle of evaporation, vapour transport, cloud formation, and precipitation distributes water and energy around the globe. A continuous monitoring of H_2O at global scale is very important to assess, predict and mitigate future climate change. In this context, we present a portable, very compact, commercial and very low resolution Fourier transform spectrometer for near infrared spectroscopy (ARCspectro ANIR; named here as μ-FTIR) and suitable to retrieve total column amount of H_2O.

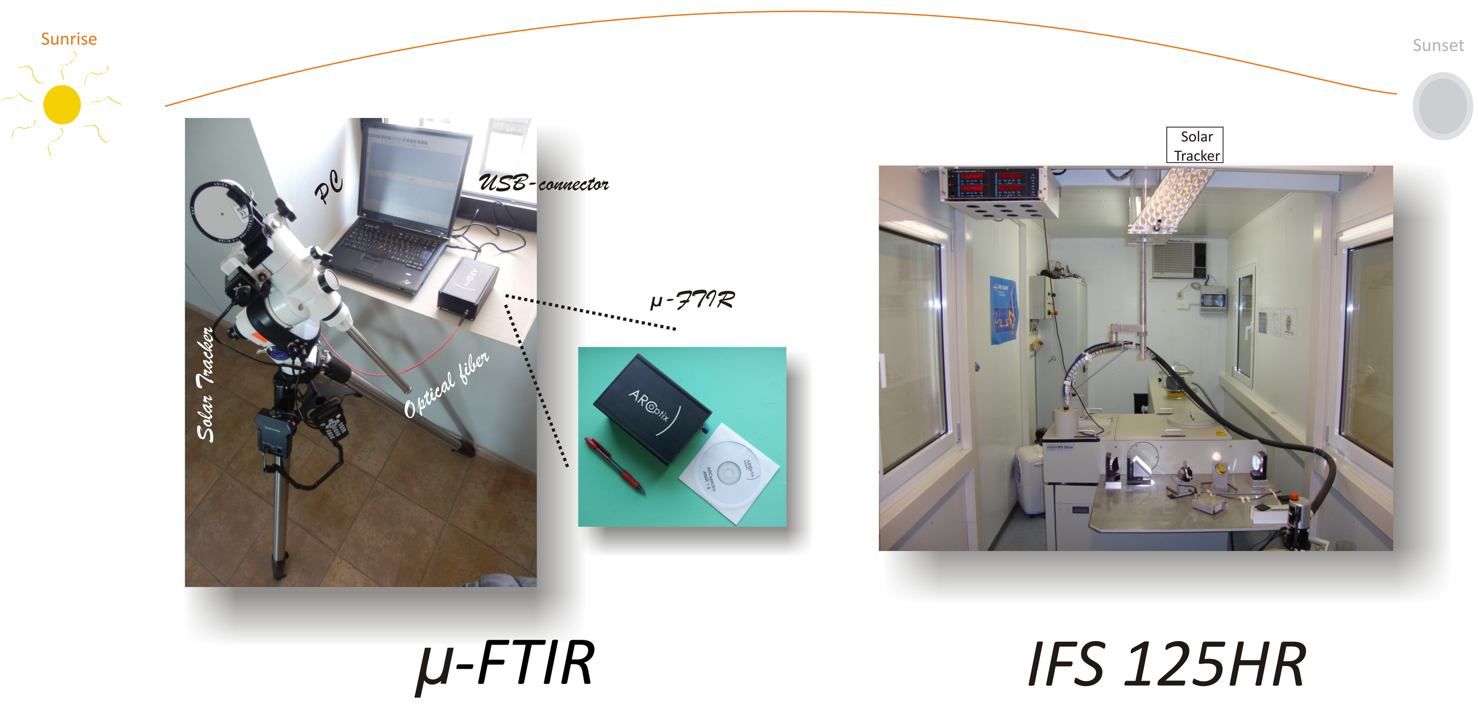
This study has been carried out at the Izaña observatory. First results are compared with high quality H_2O total column amounts obtained by a collocated non-mobile high resolution Fourier transform spectrometer (Bruker IFS 125HR). This inter-comparison documents that the very low resolution instrument is well suitable for capturing the variability of H_2O total column amounts (precision of better than 4%), but that suffers from a significant wet bias (about 30%).

1. LOCATION

28°N, 17°W

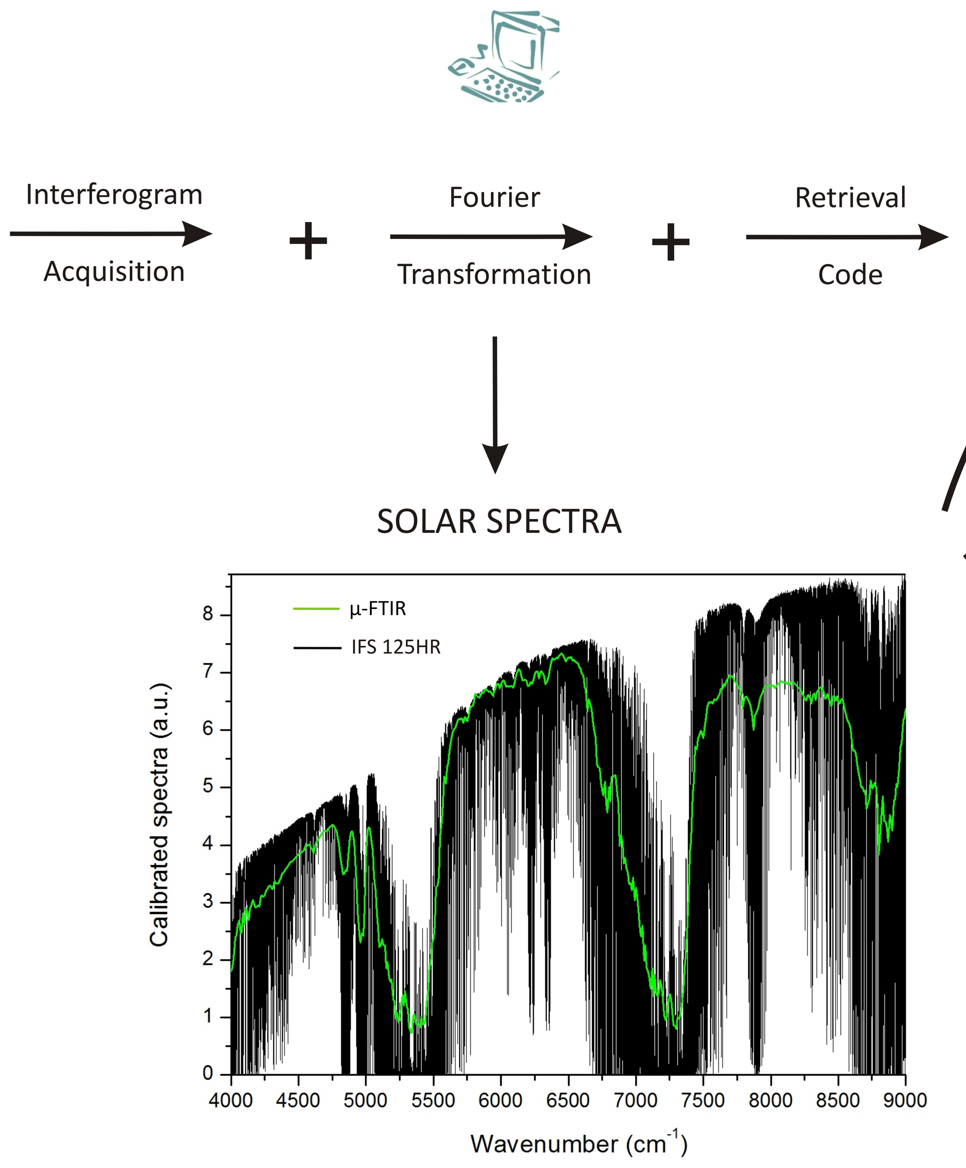
The Izaña subtropical high mountain observatory (http://www.izana.org/) is located at 2370 m.a.s.l. in the Canary Islands. The observatory is located over a strong temperature inversion layer that works as a natural barrier for local pollution and therefore is well representative for atmospheric background conditions. It is a global station of the WMO (World Meteorological Organisation) network of GAW (Global Atmospheric Watch) stations and has a comprehensive measurement program of a large variety of different atmospheric constituents.

2. LOW versus HIGH RESOLUTION INSTRUMENT (μ-FTIR vs IFS 125HR)

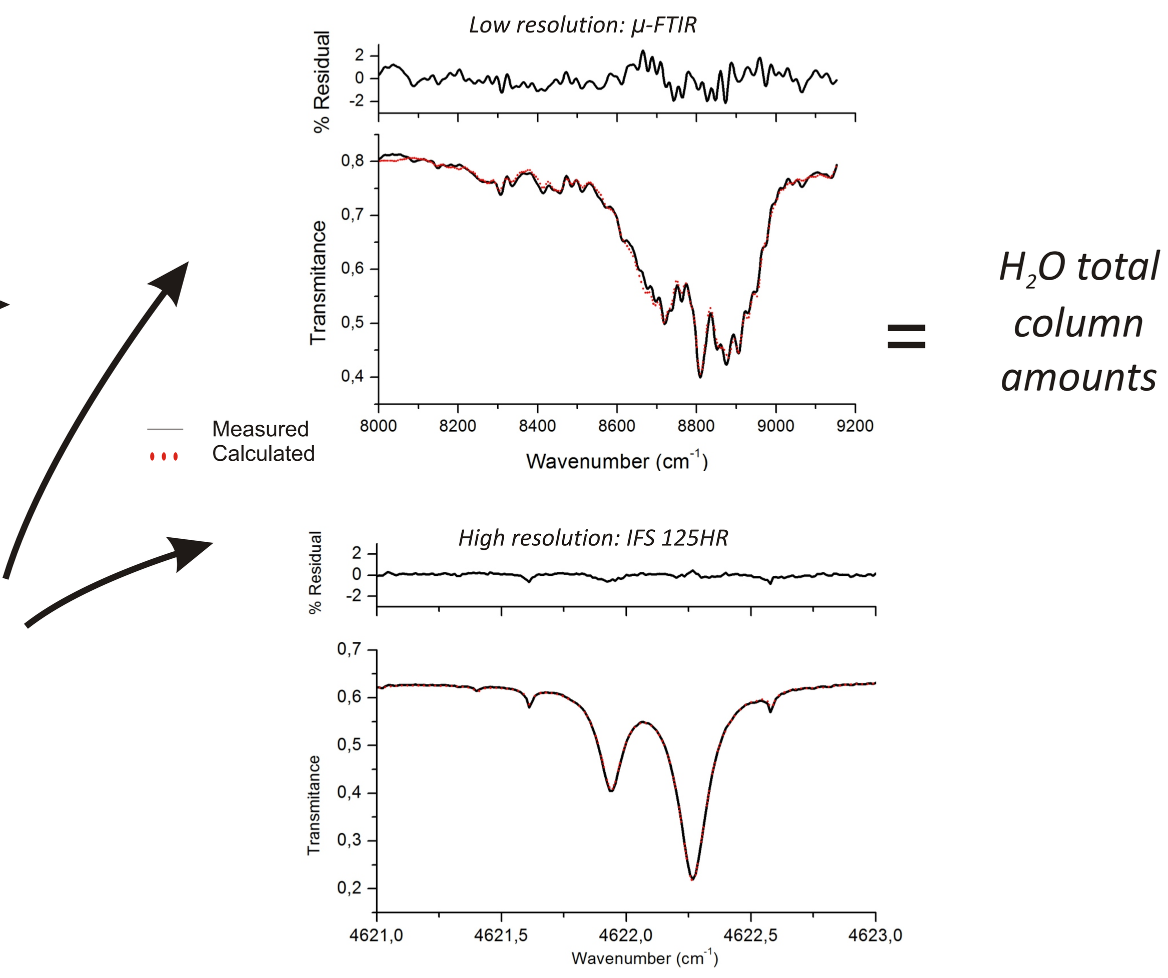


	μ-FTIR	IFS 125HR
Spectral resolution	18 cm^{-1}	0.02 cm^{-1}
Solar tracker	Astronomical	Camtracker (Gisi et al., 2011)
Detector	InGaAs	InGaAs
Spectral range	3800 - 11000 cm^{-1}	4000 - 9000 cm^{-1}
Beamsplitter	NONE	CaF_2
Measurement time	< 2 min	3 min
	fiber-coupled	

Detail information for the μ-FTIR can be found in http://www.ftir-spectrometer.com
for the Bruker IFS 125HR in http://www.brukeroptics.com



Example of spectral region for the H_2O total column retrieval



The measured spectra are processed with the nonlinear least squares fitting algorithm PROFFIT developed at KIT Karlsruhe (Hase et al., 2004)

3. RESULTS: H_2O total column amounts

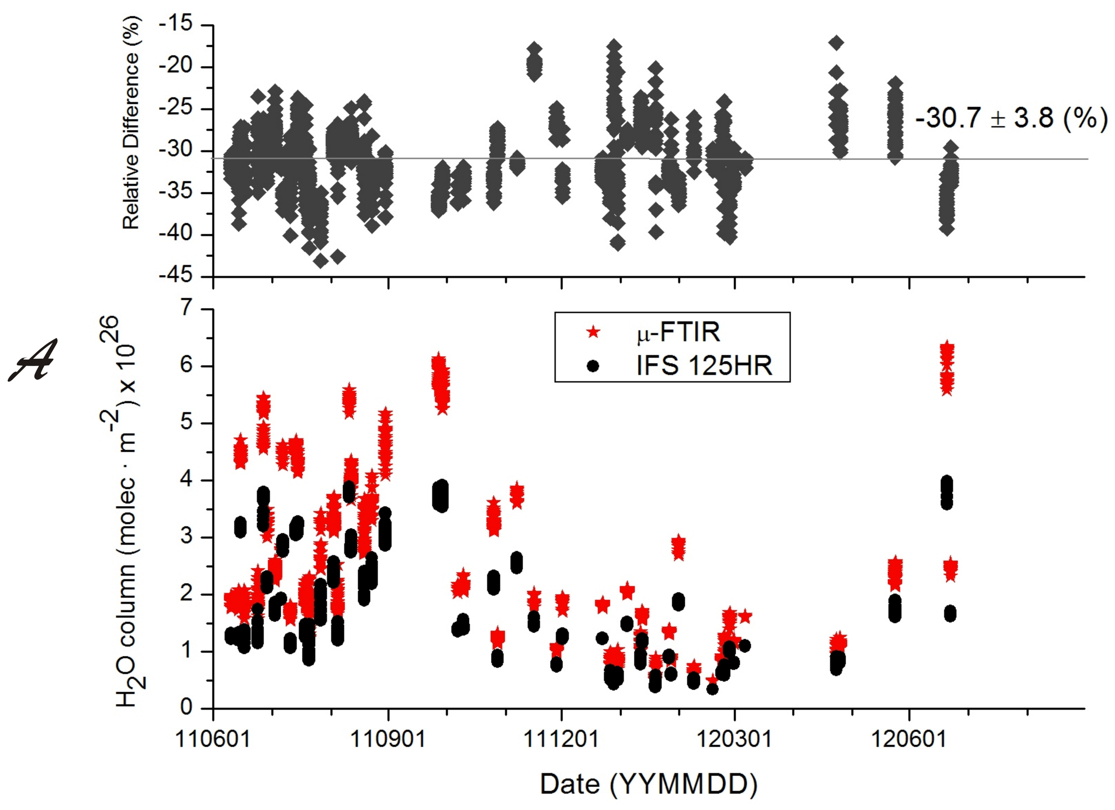


Figure *A* shows in the lower panel the H_2O total column amounts time series obtained for the μ-FTIR (red stars) and the IFS 125HR (black circles). It only considers measurements for which μ-FTIR and IFS 125HR coincide within 10 minutes (in total 1415 measurements). The upper panel depicts the relative differences. It shows a large systematic bias of 31%. However, the low standard deviation (3.8%) suggests a good repeatability of the μ-FTIR.

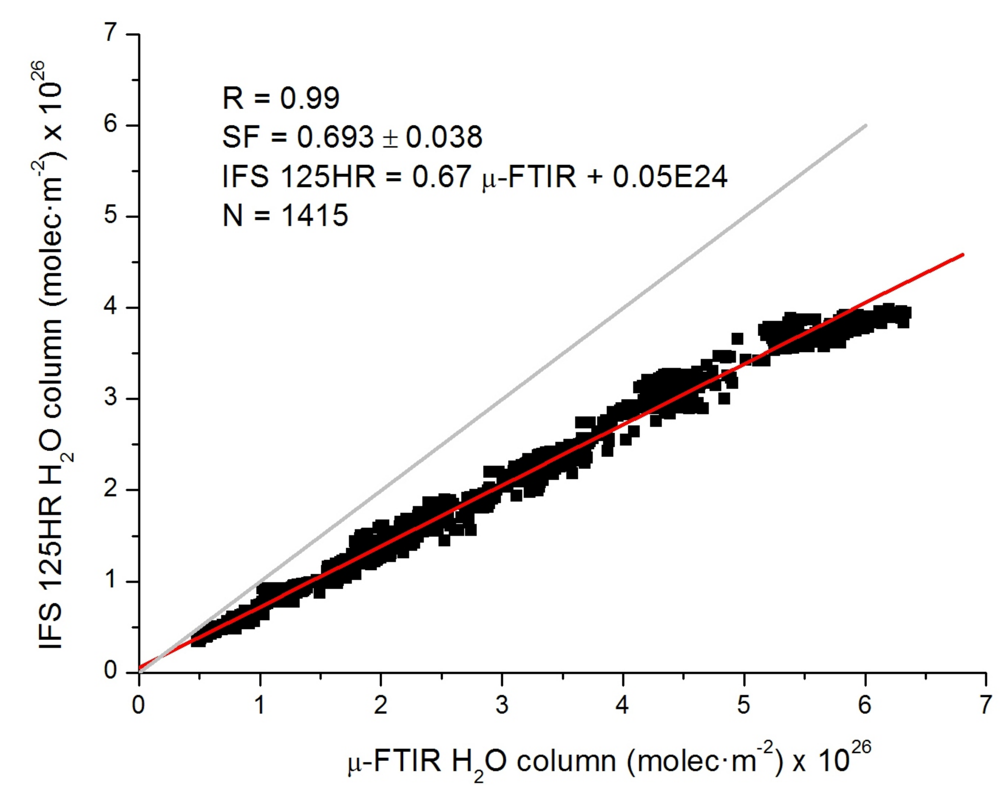


Figure *B* shows the correlation plot between H_2O total column amounts obtained from the low- and high- resolution instruments (for temporal coincidence criterion of less than 10 minutes). A high correlation factor (R=0.99) is achieved. However, the μ-FTIR significantly overestimates the IFS 125HR H_2O total column amounts (scaling factor IFS125HR / μ-FTIR of 0.7).

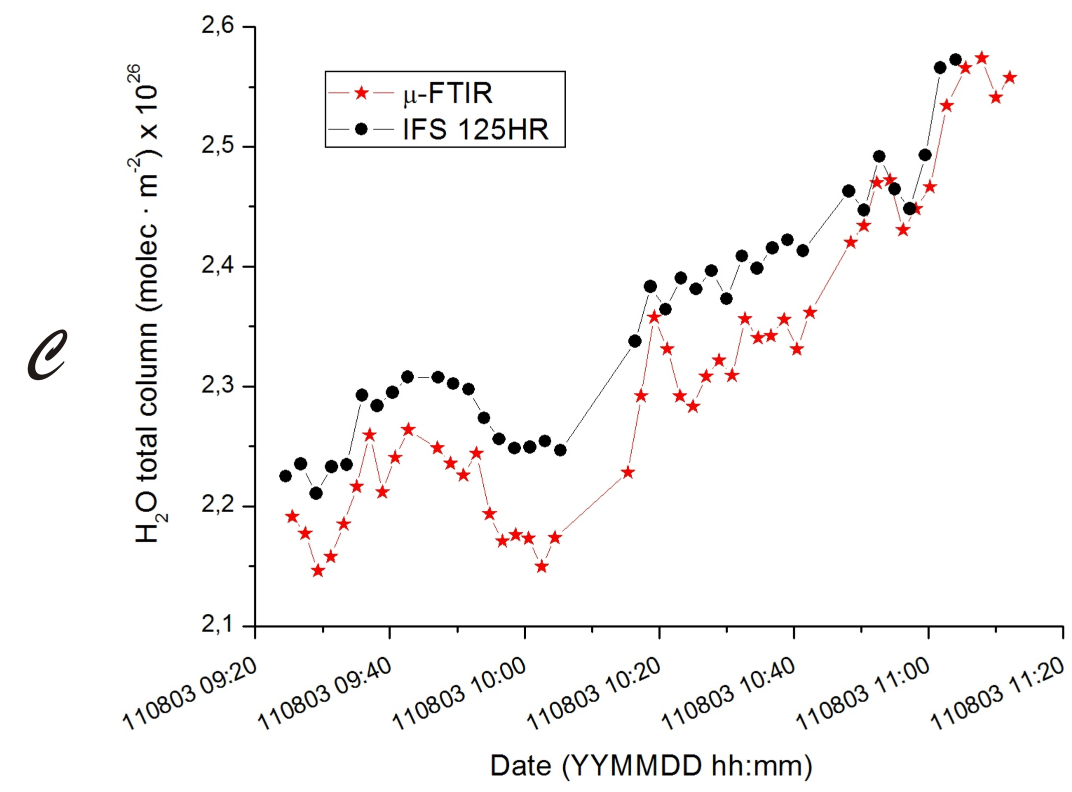


Figure *C* shows an example of variation of H_2O total column amounts during 2 hour for the μ-FTIR (red stars) and the IFS 125HR (black circles). It only considers measurements for which μ-FTIR and IFS 125HR coincide within 10 minutes. The μ-FTIR data have been scaled applying the scaling factor obtained and shown in Fig. *B*.

4. CONCLUSIONS

A portable, very compact (14.6 x 10.5 x 7 cm), commercial, lightweight (<1kg) and very low resolution (18 cm^{-1}) Fourier transform spectrometer (μ-FTIR) for the remote sensing of total column amounts of H_2O has been presented. Very low resolution spectra with a good signal-to-noise level can be acquired within every 2 minutes allowing for a high measurement frequency.

An inter-comparison with respect to collocated high resolution measurements performed at the Izaña observatory with a Bruker IFS 125HR during a year documents the repeatability quality of the μ-FTIR data (precision better than 4%), but also indicates a large wet bias. The reason for this wet bias is being currently investigated.

LITERATURE REFERENCES:

- Gisi, M., Hase, F., Dohe, S., And Blumenstock, T.: Camtracker: a new camera controlled high precision solar tracker system for FTIR-spectrometers, Atmos. Meas. Tech., 4, 47-54, 2011.
- Hase, F., Hannigan, J.W., Coffey, M. T., Goldman, A., Höpfner, M., Jones, N. B., Rinsland, C. P., and Wood, S. W.: Intercomparison of retrieval codes used for the analysis of high-resolution, ground-based FTIR measurements, J. Quant.

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